Management of Timothy for Silage

1998 and 1999 growing seasons

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104-02117/

Research supported by:
-Agriculture and Agri-Food Canada, Matching Investment Initiative
-DSV Deutsche Saatenveredelung

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Management of Timothy for Silage

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Abstract

Timothy (*Phleum pratense* L.) is the most widely grown forage grass in Eastern Canada. Traditional cultivar development has emphasized yield capacity. Other characteristics such as nutritional quality and persistence under intensive management practices are of importance in modern forage production. Assessing new breeding material for these characteristics is crucial in developing superior cultivars. Very little breeding of timothy is done in Canada and USA, making us increasingly dependent on new cultivars developed under different environmental conditions. At the Crops and Livestock Research Centre in Charlottetown ten advanced breeding lines from Germany and four currently recommended cultivars were evaluated for dry matter yield production and forage quality parameters. Nine lines matured like the intermediate check cultivar Climax. Average total DM yield was 11.96 t ha^{-1} over the two production years. Seven breeding lines outyielded Climax by 2 to 7 percent. In the two year average, relative CP concentrations of the breeding lines ranged from 82 to 93% of the check cultivar Climax, relative NDF concentrations from 101 to 104% and ADF concentrations from 100 to 105%. Lower CP and higher fibre concentrations of several entries indicate a higher proportion of stems in the herbage. After two years of testing two breeding lines are recommended for further development.

Introduction

Timothy (*Phleum pratense* L.) is the most widely grown forage grass in Eastern Canada. It is a highly persistent grass species which reliably produces high yields with good nutritional quality under intensive management. Timothy is mainly used for conserved feed but there is growing demand for pasture varieties.

Traditional cultivar development has emphasized yield capacity. Yield potential continues to be a primary selection criterion in timothy breeding but substantial yield increases have been difficult to achieve (Berg et al. 1996). Other characteristics such as nutritional quality, persistence under intensive management practices and N utilization efficiency are of importance in modern forage production. Assessing new breeding material for these characteristics is crucial in developing superior cultivars.

Selection for improved nutritive value of some permanent grasses has been successful (Jung and Casler 1990). Bélanger and McQueen (1997) suggested that improvement for nutritive value in timothy should be possible. In a study conducted near Quebec, PQ, differences in N utilization efficiency of field grown timothy populations were detected (Michaud et al. 1998). Mika (1983) in Europe and Bélanger and McQueen (1996) in Eastern Canada concluded that digestibility of early maturing cultivars was greater than that of late maturing cultivars at the same morphological stage. Differences in digestibility and NDF concentration between early and late maturing cultivars were not only related to the proportion of leaf blades in the biomass (Bélanger and McQueen 1996). The nutritive value of leaves and stems of early maturing cultivars was also greater than that of late maturing cultivars at a given stage of maturity (Bélanger and McQueen 1997). These results emphasize the importance of taking the stage of maturity in account when comparing timothy cultivars for yield and nutritive value.

Recent studies conducted at two latitudes (46• N and 61• N) indicate that yields, plant characteristics and fibre composition of timothy were dependent on the origin of timothy cultivar and production site (Kunelius et al. 1995). This study also shows that it should be possible to improve regrowth, leafiness, crude protein, and concentration of P, Ca and Mg of new timothy cultivars.

Improving nutritive value and N utilization efficiency seems a realistic and achievable goal. Improved cultivars are required for sustainable silage and pasture farming. However, very little breeding of timothy is done in Canada and USA, making us increasingly dependent on new cultivars developed under environmental conditions considerably different from ours.

The objective of this study was to determine yield potential, nutritive value, persistence and growth characteristics of timothy breeding lines from central Europe in comparison to several cultivars recommended by the Atlantic Field Crops Committee (1999a).

Materials and Methods

The experiment was conducted at Harrington Farm of the Crops and Livestock Research Centre in Charlottetown, Prince Edward Island, Canada (46• N, 63• W, 23 m above sea level). The soil type was a fine sandy loam, an Orthic Humo-Ferric Podzol with a pH of 6.4 and medium contents of phosphate, potash, calcium and magnesium (Table 1). Previous crop was barley. The field was fertilized with 70 kg ha^{-1} of N, P and K before seeding. Timothy cultivars were broadcast seeded at a rate of 10 kg ha^{-1} with an Øyjord small plot drill and rolled after seeding in June 1997. Fertilizer rates and times of application appear in Table 2.

The experiment was set up as a randomized complete block design with 14 timothy cultivars in three replicates. The plot size was 1.5 x 5 m. The cultivars tested comprised four recommended cultivars of varying maturity (early: 'Richmond', intermediate: 'Climax', late: 'Farol', 'Comtal') and ten advanced breeding lines from DSV - Deutsche Saatenveredelung, Lippstadt, Germany. The cutting schedule was determined to follow the rules of the Atlantic Field Crops Committee (1999b). The first cut was harvested at growth stage 3.3-3.4 - inflorescence emerged / peduncle partially elongated - according to the Moore scale (Moore et al. 1991). The following harvests were scheduled to be taken at 40-50 days intervals. The experiment was harvested once in the establishment year 1997, twice in 1998 and three times in 1999 (Table 2).

Plots were harvested with a Haldrup forage plot harvester (J. Haldrup, Løgstor, Denmark) at 8 cm stubble height. Sub samples of 350 g of chopped fresh herbage (2-4 cm long) were collected from each plot and dry matter (DM) was determined after drying at 65• C for 48 hours. An additional sub sample was freeze-dried and ground in a Wiley mill to pass a 1 mm screen before analyzing forage quality parameters. Total nitrogen (N) was determined by a combustion method with the LECO-CNS-1000 analyzer (LECO Instruments Ltd., Mississauga, ON) and expressed as crude protein (CP: percent N x 6.25). Mineral composition (Ca, Mg, Na, P, K, Cu, Zn, Mn, Fe, B, S) was analyzed by inductively coupled argon plasma spectrometry after dry ashing and extracting in dilute HCl (Thermo Jarrell Ash Corp. 1100, Waltham, MA). Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined with the ANKOM Fiber Analyzer F 200 (ANKOM Technology Corp., Fairport, NY) based on Goering and Van Soest (1970).

Analysis of variance was performed on individual cuts, annual and combined two year data for DM yields, crude protein and fibre composition and on combined data only for minerals, using the statistical program GENSTAT (Genstat 5 Committee, 1993).

The experiment was repeated by the Nova Scotia Department of Agriculture and Marketing at Truro. The 1997 seeding failed because of drought and the experiment was re-seeded on June 2, 1998. Fertilizer rates and dates of application are given in Table 2. The experiment was harvested three times in 1999 (Table 2). Forage quality parameters were not determined at Truro.

Table 1: Soil testing results for Charlottetown and Truro

Site	Date	pH	OM %	P_2O_5 ppm	K_2O ppm	Ca ppm	Mg ppm
Ch'town	Oct. 97	6.4	4.0	216-244	73-80	1022-1162	185-203
	Nov. 98	6.2	4.2	220-277	69-84	1085-1277	194-230
	Nov. 99	6.2	4.1	179-246	46-55	895-1044	157-194
Truro		6.5	2.7	731	191	1748	488

Table 2: Fertilizer application dates, types and rates and harvest dates for timothy lines and cultivars at Charlottetown and Truro.

	Charlottetown				Truro			
	Date	Type	Rate (kg ha^{-1})	Date of harvest	Date	Type	Rate (kg ha^{-1})	Date of harvest
1997	June	17-17-17	400					
	Aug 15	15-5-15	300	Sep 3				
1998	April 23	17-17-17	500	June 15/22	May 21	17-17-17	400	
	June 24	34-0-0	200	Aug 6/11	Aug 5	34-0-0	150	
	Aug 15	15-5-15	300					
1999	May 4	17-17-17	500	June 15	May 12	21-6-18	400	
	June 18	34-0-0	200	Aug 5	May 28	34-0-0	100	June 14
	Aug 6	15-5-15	300	Sep 28	June 10	21-6-18	250	July 29
					Aug 3	18-6-18	250	Oct 20

Results and Discussion

Dry Matter Yields

Dry matter yields in the establishment year ranged from 2.40 to 3.41 t ha^{-1} (Table 3). The highest yielding lines were 'WL 1264', 'WL 1297', 'WL 1296' and 'WL 1090' and cv. Richmond which also had the highest proportion of reproductive tillers in the biomass at the time of harvest.

In the first production year 'WL 1142' was similar in maturity to Richmond. Accordingly, both were harvested six days earlier than Climax. All other breeding lines resembled Climax in maturity and differentiation among them was marginal. Since there were no late maturing breeding lines, Comtal and Farol were harvested at the same time as Climax. Total DM yields varied between 13.80 (WL 1296) and 11.50 t ha^{-1} (Farol). All timothy lines had higher total DM yields than the check cultivar Climax, seven of which were statistically significant (P=0.025). Dry matter yield of cut 1 comprised 0.63 of total yield. Regrowth after cut 2 was slow following a hot and dry period so that the experiment was not harvested again.

In the second production year all plots were harvested at the same dates because of minimal differentiation in maturity. Average total DM yield was 2 t ha^{-1} lower than in the previous year. DM yields ranged from 10.11 ('WL 1081', Farol) to 11.80 t ha^{-1} (WL 1264) and were not statistically different (P>0.05). Although most of the lines outyielded Climax, some of them could not repeat their strong relative performance, most notably WL 1081 which achieved only 94% of the check compared to 104% in the first production year. Relative yield of WL 1264 increased from 104% in 1998 to 110% in the second production year. DM yields at cut 1 were only slightly lower in the second production year, but were drastically reduced at cut 2. Regrowth was suppressed by drought and high temperatures.

Over the two years seven breeding lines outyielded Climax by 2 to 7 percent. For WL 1264 with an average yield of 12.61 t DM ha^{-1} the difference is statistically significant (P=0.01).

Visual ratings taking at various stages over the two production years confirm the strong performances of the lines WL 1264 and WL 1297 with above average results (Table 9). The two lines with the highest visual ratings (WL 1090 and WL 1081) did not show improved DM production compared to Climax over the two year testing period. The early maturing type WL 1142, although not different from Climax in DM yield, had the lowest visual ratings of all entries.

At the second experimental site in Truro, Nova Scotia, DM yields in the first production year were as high as in Charlottetown (Table 4). However, the seasonal distribution was more uniform with 6.6, 2.8 and 2.5 t ha^{-1} in cuts 1, 2 and 3, respectively. There were no significant cultivar differences in either of the three cuts or total yields (P>0.05). Total DM yields ranged from 12.76 (WL 1081) to 10.22 t ha^{-1} (Climax). All breeding lines had higher yields than the check cultivar Climax. Six lines outyielded Climax by more than 20% or 2 t DM ha^{-1}.

Crude Protein Concentration

In the first production year crude protein concentrations in cut 1 ranged from 63 ('WL 1209') to 102 g kg^{-1} DM (Climax; Table 5). Although the first harvest was at a relatively advanced developmental stage (heads emerged), these are low and unsatisfactory levels of crude protein, which can be partly explained by the early date of fertilizer application in spring and following lack of precipitation. All breeding lines had lower CP concentrations than the check cultivar Climax, but only five were significantly different (P=0.039). Average CP concentrations in cut 2 were 40 g kg^{-1} DM higher than in cut 1. In the annual average five breeding lines had significantly lower CP concentrations than the check (P=0.009).

Average CP concentration in cut 1 of the second production year was 107 g kg^{-1} DM, slightly higher than in the previous year. Crude Protein concentration nearly doubled to 205 g kg^{-1} DM in cut 2 and remained at a high level of 172 g kg^{-1} DM in cut 3, although the regrowth period was as long as 7.5 weeks. As DM yields in both cuts were very low, the high CP levels are likely caused by a concentration effect occurring with growth inhibition during hot and dry conditions. There were no significant cultivar differences in cuts 1 and 3 (P>0.05). In the annual average only one line ('WL 1298') and the early cultivar Richmond had lower CP concentrations than Climax (P=0.018).

In the two year average, relative CP concentrations of the breeding lines ranged from 82 to 93% of the check cultivar Climax. The lines with the highest CP concentrations were WL 1142, WL 1297, WL 1081 and WL 1264. The remaining six lines had significantly lower CP concentrations than the check (P=0.029).

Fibre Concentration

Average NDF concentration in cut 1 of the first production year was 679 g kg^{-1} DM and ranged from 632 (Richmond) to 714 g kg^{-1} DM (WL 1090; Table 6). NDF concentration was 80 g

kg^{-1} DM lower in cut 2. In the annual mean the lines WL 1209, WL 1238 and WL 1090 had significantly higher NDF concentration than the check Climax ($P<.001$). Among the breeding lines only one (WL 1142) had a lower NDF concentration than Climax ($P<.001$).

Average ADF concentration varied between 339 (Farol) and 402 g kg^{-1} DM (WL 1090) in cut 1 and between 302 (Comtal) and 328 g kg^{-1} DM (WL 1090) in cut 2 (Table 7). In the annual mean the three lines with the highest NDF concentration also had significantly higher ADF concentrations than the check cultivar Climax ($P<.001$). Richmond and Farol had significantly lower NDF and ADF concentrations than Climax.

Fibre concentrations in the second production year were generally slightly lower than in the first. There was no significant cultivar effect on NDF concentration in cut 1 ($P>0.05$; Table 7.) In cuts 2 and 3, all breeding lines and cultivars had higher NDF concentrations than Climax. Mean annual NDF concentrations ranged from 591 (Farol) to 623 g kg^{-1} DM (WL 1296, WL 1298). Seven breeding lines had significantly higher NDF concentrations than Climax ($P=0.013$).

In cut 1 of the second production year WL 1296 had a significantly higher ADF concentration than Climax($P=0.024$, Table 6). There were no cultivar differences in cut 2 ($P>0.05$) and in cut 3 Climax had significantly lower ADF than all other entries. Mean annual ADF concentrations in the second production year varied between 317 (Farol) and 344 g kg^{-1} DM (WL 1296).

Generally fibre concentrations in both production years were very high, probably reflecting the hot and dry growing conditions. In the two year average relative NDF concentrations of the breeding lines ranged from 101 to 104% and ADF concentrations from 100 to 105% of the check cultivar Climax. Mean fibre concentrations of WL 1081, WL 1142 and WL 1297 were not significantly different from the check. Compared to Climax slightly elevated fibre concentrations of the majority of the breeding lines in combinations with the somewhat higher yield potential may indicate a higher proportion of stems, particularly reproductive tillers, in the herbage.

Mineral Composition

Cultivar effects on mineral composition were observed for the macro elements P, K, Ca, Mg and the micro nutrients Mn, Fe and B (Table 7). No differences were found for Na, Cu, Zn and S. Among the breeding lines the comparatively early maturing type WL 1142 stands out with above average concentrations for all elements. The highest yielding lines WL 1264, WL 1296 and WL 1297 had mineral contents slightly, but generally not significantly lower than the check Climax.

Conclusions

The breeding lines evaluated in this experiment showed little differentiation in maturity. Nine lines were similar in maturity to the intermediate check cultivar Climax. WL 1142 seems to be an earlier maturing type similar to Richmond.

In a two year average all breeding lines produced DM yields equal to or higher than the

check. WL 1264, WL 1297 and WL 1296 were the highest yielding lines at Charlottetown.

Forage quality parameters of the breeding lines generally were similar to the check Climax. Lower CP and higher fibre concentrations of several entries indicate a higher proportion of stems in the herbage.

WL 1264 and WL 1297 achieved the best overall performance, including high visual ratings, and could be a valuable addition to the cultivar inventory. The early type WL 1142 had average DM yields and the best forage quality, however, it received the poorest visual rating in the field. Of the two lines with the highest visual ratings, WL 1081 did not maintain its high DM production in the second harvest year and WL 1090 did not sustain the level of forage quality of the check Climax.

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Acknowledgments

Technical assistance by Douglas Lea, Nancy Gormley, Basil Dickson and Alden Knight (Truro) is gratefully acknowledged.

Table 3: Dry matter yields (t ha^{-1} and relative: 'Climax' = 100) of timothy lines and cultivars in establishment year (1997) and production years 1998 and 1999; location: Charlottetown, PEI

	1997		1998				1999					2yr Average	
Cultivar / Line	**Cut 1**	*rel.*	**Cut 1**	**Cut 2**	**Total**	*rel.*	**Cut 1**	**Cut2**	**Cut 3**	**Total**	*rel.*	**Total**	*rel.*
WL 930	2.85	*103*	8.04	4.83	12.88	*100*	7.79	1.80	1.72	11.30	*105*	12.09	*102*
WL 1081	2.84	*102*	7.90	5.52	13.42	*104*	6.69	2.03	1.55	10.11	*94*	11.76	*100*
WL 1090	3.07	*110*	7.92	4.64	12.56	*97*	8.07	1.40	1.65	11.12	*103*	11.84	*100*
WL 1142	2.59	*93*	7.29	5.26	12.55	*97*	7.97	1.51	1.59	11.07	*103*	11.81	*100*
WL 1209	2.76	*99*	9.05	4.67	13.68	*106*	7.52	1.83	1.46	10.82	*101*	12.25	*104*
WL 1238	2.84	*102*	8.50	4.79	13.28	*103*	8.00	1.65	1.66	11.31	*105*	12.30	*104*
WL 1264	3.41	*123*	8.43	5.00	13.42	*104*	8.62	1.40	1.77	11.80	*110*	12.61	*107*
WL 1296	3.09	*111*	8.63	5.17	13.80	*107*	7.73	1.83	1.58	11.14	*104*	12.47	*106*
WL 1297	3.41	*123*	8.42	5.29	13.71	*106*	7.86	1.89	1.55	11.31	*105*	12.51	*106*
WL 1298	2.40	*86*	8.78	4.57	13.35	*103*	7.78	1.47	1.42	10.67	*99*	12.00	*102*
Richmond	3.25	*117*	7.38	4.89	12.27	*95*	7.84	1.62	1.65	11.12	*103*	11.69	*99*
Climax	2.78	*100*	8.40	4.46	12.90	*100*	7.72	1.51	1.53	10.76	*100*	11.81	*100*
Farol	2.62	*94*	7.48	4.02	11.50	*89*	6.98	1.55	1.58	10.11	*94*	10.81	*92*
Comtal	2.63	*95*	8.43	3.81	12.24	*95*	7.38	1.69	1.74	10.81	*100*	11.52	*98*
Mean	2.90		8.19	4.78	12.97		7.71	1.66	1.61	10.96		11.96	
CV (%)	15.0		7.3	6.4	4.6		7.4	19.2	8.2	6.2		4.0	
SEM (n=3, df 13)	0.25		0.34	0.18	0.35		0.33	0.18	0.08	0.39		0.28	
F prob	0.176		0.025	<.001	0.002		0.057	0.373	0.105	0.235		0.01	
$LSD_{0.05}$	n.s.		1.00	0.51	1.01		n.s.	n.s.	n.s.	n.s.		0.80	

Table 4: *Dry matter yields (t ha^{-1} and relative; 'Climax' = 100) of timothy lines and cultivars in first production year 1999; location: Truro, NS*

	1999				
Cultivar / Line	**Cut 1**	**Cut2**	**Cut 3**	**Total**	*rel.*
WL 930	6.13	2.74	2.29	11.16	*109*
WL 1081	6.57	3.54	2.65	12.76	*125*
WL 1090	7.09	3.02	2.47	12.57	*123*
WL 1142	6.88	2.83	2.60	12.31	*120*
WL 1209	6.48	2.86	2.23	11.56	*113*
WL 1238	7.07	2.77	2.28	12.12	*119*
WL 1264	6.84	2.70	2.48	12.01	*118*
WL 1296	6.71	3.17	2.68	12.57	*123*
WL 1297	6.64	3.29	2.68	12.57	*123*
WL 1298	6.77	3.23	2.68	12.68	*124*
Richmond	6.75	2.78	2.64	12.17	*119*
Climax	5.93	2.37	1.92	10.22	*100*
Farol	5.76	2.26	2.96	10.97	*107*
Comtal	6.48	2.33	2.32	11.13	*109*
Mean	6.58	2.85	2.49	11.91	
CV (%)	9.1	22.7	15.3	12.7	
SEM (n=3, df 13)	0.30	0.32	0.19	0.759	
F prob	0.087	0.22	0.064	0.42	
$LSD_{0.05}$	n.s.	n.s.	n.s.	n.s.	

Table 5: Crude protein contents (g kg^{-1} DM and relative; 'Climax' = 100) of timothy lines and cultivars in production years 1998 and 1999; location: Charlottetown, PEI

	1998				1999					2yr Average	
Cultivar / Line	**Cut 1**	**Cut 2**	**Mean**	*rel.*	**Cut 1**	**Cut 2**	**Cut 3**	**Mean**	*rel.*	**Mean**	*rel.*
WL 930	73	117	89	*80*	105	202	170	131	*93*	110	*87*
WL 1081	76	116	92	*83*	106	192	192	137	*97*	115	*91*
WL 1090	78	120	94	*85*	107	207	190	132	*94*	113	*90*
WL 1142	89	115	104	*94*	108	203	171	130	*92*	117	*93*
WL 1209	63	116	81	*73*	109	219	173	136	*96*	109	*87*
WL 1238	75	119	91	*82*	108	222	185	136	*96*	113	*90*
WL 1264	81	142	104	*94*	104	218	165	127	*90*	115	*91*
WL 1296	87	120	100	*90*	97	204	169	126	*89*	113	*90*
WL 1297	83	118	96	*86*	118	186	161	135	*96*	116	*92*
WL 1298	85	101	97	*87*	83	193	164	109	*77*	103	*82*
Richmond	87	120	100	*90*	96	192	159	119	*84*	110	*87*
Climax	102	128	111	*100*	119	216	182	141	*100*	126	*100*
Farol	100	137	113	*102*	116	218	162	139	*99*	126	*100*
Comtal	95	141	109	*98*	115	201	161	136	*96*	123	*98*
Mean	84	124	99		107	205	172	131		115	
CV (%)	14.9	8.4	9.2		12.2	5.2	8.9	7.0		6.4	
SEM (n=3, df 13)	7.2	6.0	5.2		7.5	6.1	8.8	5.3		4.2	
F prob	0.039	0.033	0.009		0.142	0.002	0.144	0.018		0.029	
$LSD_{0.05}$	21	18	15		n.s.	18	n.s.	15		12	

Table 6: NDF contents (g kg^{-1} DM and relative; 'Climax' = 100) of timothy lines and cultivars in production years 1998 and 1999; location: Charlottetown, PEI

	1998				1999					2yr Average	
Cultivar / Line	**Cut 1**	**Cut 2**	**Mean**	*rel.*	**Cut 1**	**Cut 2**	**Cut 3**	**Mean**	*rel.*	**Mean**	*rel.*
WL 930	693	606	660	*102*	642	547	559	614	*103*	637	*103*
WL 1081	677	616	652	*101*	640	546	535	606	*102*	629	*101*
WL 1090	714	590	668	*104*	638	534	546	611	*103*	639	*103*
WL 1142	660	616	631	*98*	644	542	562	618	*104*	624	*101*
WL 1209	707	611	675	*105*	634	538	553	607	*102*	641	*103*
WL 1238	704	609	670	*104*	653	531	555	621	*104*	645	*104*
WL 1264	700	591	659	*102*	644	533	565	619	*104*	639	*103*
WL 1296	687	608	657	*102*	656	540	562	623	*105*	640	*103*
WL 1297	676	611	651	*101*	622	534	556	598	*100*	625	*101*
WL 1298	681	596	651	*101*	653	529	555	623	*105*	637	*103*
Richmond	632	581	612	*95*	646	535	554	616	*103*	614	*99*
Climax	672	592	644	*100*	623	515	530	596	*100*	620	*100*
Farol	639	603	626	*97*	613	531	551	591	*99*	608	*98*
Comtal	672	581	644	*100*	640	523	536	605	*102*	624	*101*
Mean	679	599	650		639	534	551	611		630	
CV (%)	2.0	1.8	1.6		2.4	1.9	1.8	1.8		1.3	
SEM (n=3, df 13)	7.9	6.3	6.1		9.0	5.9	5.8	6.3		4.8	
F prob	<.001	0.003	<.001		0.075	0.047	0.004	0.013		<.001	
$LSD_{0.05}$	23	18	18		n.s.	17	17	18		14	

Table 7: ADF contents (g kg^{-1} DM and relative; 'Climax' = 100) of timothy lines and cultivars in production years 1998 and 1999; location: Charlottetown, PEI

	1998				1999					2yr Average	
Cultivar / Line	**Cut 1**	**Cut 2**	**Mean**	*rel.*	**Cut 1**	**Cut 2**	**Cut 3**	**Mean**	*rel.*	**Mean**	*rel.*
WL 930	389	325	365	*104*	347	285	293	328	*102*	347	*103*
WL 1081	380	326	358	*102*	355	287	287	331	*102*	344	*102*
WL 1090	402	316	369	*105*	341	280	285	325	*101*	347	*103*
WL 1142	374	321	352	*100*	354	283	298	336	*104*	344	*102*
WL 1209	399	328	375	*107*	344	287	288	327	*101*	351	*104*
WL 1238	398	325	371	*105*	357	280	294	336	*104*	354	*105*
WL 1264	391	318	363	*103*	356	282	296	339	*105*	351	*104*
WL 1296	386	322	362	*103*	367	283	305	344	*107*	353	*104*
WL 1297	377	319	355	*101*	334	280	294	319	*99*	337	*100*
WL 1298	370	312	351	*100*	361	282	285	340	*105*	345	*102*
Richmond	347	308	332	*94*	359	275	292	337	*104*	334	*99*
Climax	372	313	352	*100*	342	276	273	323	*100*	338	*100*
Farol	339	312	330	*94*	329	286	294	317	*98*	323	*96*
Comtal	368	302	348	*99*	346	279	288	326	*101*	337	*100*
Mean	378	318	356		349	282	291	331		343	
CV (%)	3.0	2.5	2.3		3.4	2.1	2.4	2.5		1.9	
SEM (n=3, df 13)	6.5	4.6	4.7		6.9	3.4	4.0	4.8		3.7	
F prob	<.001	0.02	<.001		0.024	0.317	0.003	0.010		<.001	
$LSD_{0.05}$	19	14	14		20	n.s.	12	14		11	

Table 8: Mineral composition (P, K, Ca, Mg, Na, S in g kg^{-1} DM; Cu, Zn, Mn, Fe, B ppm) of timothy lines and cultivars; 2 year average from production years 1998 and 1999; location: Charlottetown, PEI

Cultivar / Line		P	K	Ca	Mg	Na	Cu	Zn	Mn	Fe	B	S
WL 930		2.55	21.1	3.87	1.98	0.14	3.71	19.4	53.5	61.6	5.41	1.47
WL 1081		2.42	20.6	4.00	2.03	0.15	3.68	21.3	60.1	60.0	5.97	1.44
WL 1090		2.45	20.3	3.27	1.81	0.14	3.50	18.6	41.5	53.8	4.47	1.42
WL 1142		2.62	22.1	4.20	2.12	0.16	3.67	21.00	54.5	107.5	6.21	1.64
WL 1209		2.38	19.4	3.29	1.73	0.12	3.17	17.9	48.0	49.2	4.80	1.29
WL 1238		2.48	20.7	3.32	1.83	0.14	3.36	19.8	51.3	54.5	4.75	1.39
WL 1264		2.50	20.9	3.51	1.94	0.13	3.43	19.8	55.0	61.9	4.92	1.44
WL 1296		2.49	20.1	3.30	1.91	0.16	3.59	20.7	62.0	60.1	4.57	1.41
WL 1297		2.48	20.0	3.63	1.90	0.14	3.75	20.1	48.1	64.2	5.42	1.45
WL 1298		2.35	20.1	3.34	1.70	0.13	3.38	17.5	44.4	49.7	4.78	1.36
Richmond		2.43	19.8	4.00	2.13	0.14	3.77	19.9	53.2	69.9	6.28	1.44
Climax		2.65	21.2	3.61	1.94	0.14	3.86	21.5	50.0	58.8	5.45	1.45
Farol		2.74	22.7	3.70	2.13	0.15	3.76	18.6	68.5	91.5	5.70	1.53
Comtal		2.59	21.9	3.67	1.82	0.15	3.58	19.8	56.5	69.6	5.64	1.53
Mean		2.51	20.8	3.62	1.93	0.14	3.59	19.7	53.3	65.2	5.31	1.45
CV (%)		4.8	3.1	5.9	6.7	9.9	8.2	9.4	14.4	24.4	7.5	9.2
SEM (n=3, df 13)		0.07	0.4	0.12	0.07	0.01	0.17	1.1	4.44	9.2	0.23	0.08
F prob		0.025	<.001	<.001	0.003	0.105	0.25	0.269	0.02	0.007	<.001	0.341
$LSD_{0.05}$		0.20	1.08	0.36	0.22	n.s.	n.s.	n.s.	12.9	26.7	0.67	n.s.
1998	Cut 1	2.06	20.2	2.76	1.20	0.11	3.15	19.6	41.3	45.1	3.64	1.25
	Cut 2	2.51	19.6	4.68	3.00	0.10	4.14	19.5	52.9	36.5	8.28	1.47
1999	Cut 1	2.57	21.9	3.40	1.64	0.13	2.88	18.9	58.4	100.6	5.02	1.56
	Cut 2	3.43	19.2	5.22	3.22	0.07	5.60	23.5	73.8	78.0	7.62	1.29
	Cut 3	3.24	21.8	4.08	2.37	0.50	5.35	20.2	60.7	42.0	4.10	1.82

Table 9: Visual ratings of overall performance for timothy lines and cultivars in the first two production years (1998 and 1999) at Charlottetown, PEI

Cultivar / Line	Performance Spring 1998*	Uniformity June 18+	Sward Density July 9+	Performance Fall 1998+	Performance Spring 1999+	Performance Summer 1999+
WL 930	3.0	4.3	6.0	6.3	5.3	4.7
WL 1081	4.0	4.0	6.3	7.7	6.0	4.7
WL 1090	4.0	8.3	4.3	6.3	6.0	4.7
WL 1142	2.3	5.7	4.6	4.0	3.3	2.7
WL 1209	2.7	5.7	5.3	5.7	4.0	6.0
WL 1238	3.7	7.0	4.0	5.7	5.7	5.0
WL 1264	3.7	6.7	5.0	6.0	6.0	5.0
WL 1296	3.7	4.3	6.0	6.7	5.7	5.0
WL 1297	3.0	5.3	7.0	7.0	6.0	4.3
WL 1298	2.7	3.7	4.3	4.7	6.0	5.0
Richmond	3.0	5.7	5.7	5.7	5.3	5.7
Climax	2.3	7.0	3.3	5.7	4.0	5.0
Farol	3.3	6.7	6.7	6.7	3.3	6.3
Comtal	3.0	4.7	5.3	6.3	4.7	5.0
Mean	3.2	5.6	5.3	6.0	5.1	4.9
CV (%)	19.4	17.4	20.4	17.5	18.1	18.8
SEM (n=3, df 13)	0.36	0.57	0.62	0.61	0.53	0.53
F prob	0.021	<.001	0.009	0.033	0.002	0.021
$LSD_{0.05}$	1.0	1.7	1.8	1.8	1.5	1.6

Scale: * 1=very poor, 3=average, 5=excellent
+ 1=very poor, very low, 5=average, 10=excellent, very high